

Plan Recognition and Revision in Protocol-Based Care

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ABSTRACT

Automated support for protocol-based care can be viewed as a collaborative effort of two planning agents: the physician and an automated planner. Achieving this collaboration with sufficient flexibility involves a recognition of the physician's intentions and plans, and a consideration of potential revisions to the protocol's or to the guideline's therapy plan.

We propose that automated support for clinical guidelines could be enhanced considerably by an explicit, formal representation of (1) **effects of therapy-planning events (operators)** (e.g., drug administration) on domain-specific clinical parameters (e.g., hemoglobin [Hb] level), as a set of **event-effect tuples** of the type *<event, argument, relation, parameter>*, (2) a set of generic and specific **plan-revision strategies** (e.g., suspend *event* until *condition*) of the form IF *<abstraction pattern>* THEN *<revision plan>*, and (3) the **underlying goals and policies of the guideline**, as *temporal-abstraction patterns* [1] to be maintained, achieved, or avoided (Figure 1). The representation of goals and higher-level policies, combined with knowledge about the semantics of therapy-planning actions and the potential revisions to these actions can support a limited form of **plan recognition** and increase the flexibility of the system's dialogue with the physician.

For example, assume that severe anemia is detected for the second consecutive week by the automated planner, a temporal pattern that violates one of the intentions underlying the clinical protocol; and that the physician records that she intends to give the patient a transfusion of blood. This action seems to contradict the planner's suggestion (following the protocol)

of attenuating the dose of a drug toxic to the bone marrow. However, the automated planner can note that the transfusion increases the value of Hb through an external event, while the planner's recommendation increases the value of Hb by reducing the magnitude of an event (i.e., the dose of the toxic drug) that decreases its value. Thus, the physician's plan uses a recognized revision strategy and follows the guideline's policy.

Representing a clinical guideline amounts to representing a skeletal plan that needs to be refined over time; goals and policies in that plan can be represented as temporal-abstraction patterns of events and parameters to be maintained, achieved, or avoided. A plan-recognition ability is crucial to support and to *critique* [2] the physician's plans in the face of complex, ambiguous guidelines and multiple methods for achieving similar goals. Plan-recognition requires knowledge about domain-independent and domain-specific revision strategies. Reasoning about revision strategies, however, requires knowledge of qualitative relationships among event arguments and clinical-parameter values in different *contexts* (e.g., a particular clinical protocol for therapy of AIDS patients).

Explicit representation of the intentions underlying clinical guidelines, of a domain-independent knowledge base of revision mechanisms, and of event-effect tuples would contribute in at least two major ways: (1) enhanced functionality and flexibility of automated planners might increase the acceptance of their assistance in the increasingly common task of application of clinical guidelines, and (2) annotations to the guideline and clear semantics for the domain knowledge base would facilitate the maintenance and reusability of the task-specific knowledge involved in the application of such guidelines.

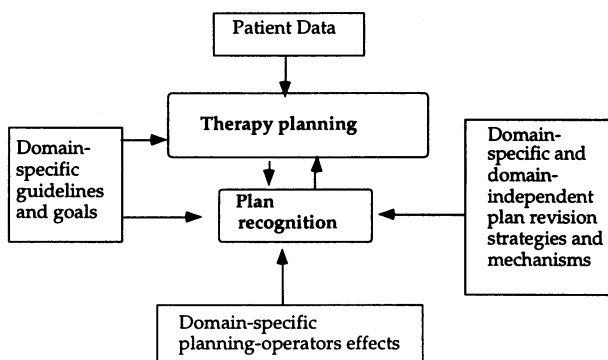


Figure 1: A Plan-recognition architecture.

References

1. Shahar Y, Musen MA. RÉSUMÉ: A temporal-abstraction system for patient monitoring. *Computers and Biomedical Research* 1993; 26:255-273. Reprinted in van Bommel, J.H., and McRay, T. (eds) *Yearbook of Medical Informatics 1994*, pp. 443-461, Stuttgart: F.K. Schattauer and The International Medical Informatics Association, 1994.
2. Miller PL. *Expert Critiquing Systems: Practice-Based Medical Consultation by Computer*. New York, NY: Springer-Verlag, 1986.